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**EVALUATION OF JSAF EM PROPAGATION PREDICTION METHODS FOR NAVY CONTINUOUS TRAINING ENVIRONMENT / FLEET SYNTHETIC TRAINING,
RESULTS AND RECOMMENDATIONS:
PART III– AN OVERVIEW OF JSAF'S ENVIRONMENTAL CAPABILITIES AND DATA**

by

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The purpose of this report is to provide an overview of JSAF with a focus on understanding the environmental capabilities, constraints, and datasets used in JSAF. This first section describes JSAF and how it is used in training. The second section briefly describes the environmental capabilities and datasets used, for the atmosphere, ocean and underwater acoustics. In the last section, a list of references that point to more comprehensive and in-depth detail on JSAF is provided.

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ABSTRACT

The purpose of this report is to provide an overview of JSAF with a focus on understanding the environmental capabilities, constraints, and datasets used in JSAF. This first section describes JSAF and how it is used in training. The second section briefly describes the environmental capabilities and datasets used, for the atmosphere, ocean and underwater acoustics. In the last section, a list of references that point to more comprehensive and in-depth detail on JSAF is provided.

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An Overview of JSAF's Environmental Capabilities and Data

1. Introduction and Overview of JSAF

The purpose of this report is to provide an overview of JSAF with a focus on understanding the environmental capabilities, constraints, and datasets used in JSAF. This first section describes JSAF and how it is typically used in training. The second section briefly describes the environmental capabilities and datasets used for the atmosphere, ocean, and underwater acoustics. In the last section, a list of references which point to more comprehensive and in-depth detail on JSAF is provided.

JSAF stands for Joint Semi-Automated Forces and is maintained by the Naval Warfare Development Command (NWDC). JSAF is a simulation system designed for training and experimentation. It runs in the Linux operating system, either as a standalone system or in a networked environment with several computers taking part in a simulation. The user interface, known as the Plan View Display or PVD (Figure 1), provides tools for an operator to create, monitor and run a training scenario. The user may select any number of air, sea, land, and underwater vehicles, and specify the country and exact model or name of the vehicle, e.g. an Iranian AUV or the USS Eisenhower. In addition to vehicles, JSAF includes people, dolphins and other life, and structures such as buildings. Complicated physical and performance behaviors are associated with each vehicle. A ship's parameters, for example, would include turning radius at a given speed, fuel consumption, and which radars and sensors and communications systems are available on that particular ship. The user can activate and configure jamming systems for those vehicles that have an Electronic Warfare (EW) capability, or sonar systems, Electronic Surveillance Measures (ESM), radar, etc. The user can set up tasks or missions for each unit, which are typically composed of move, shoot, coordinate, and react. Once the scenario begins, the display will show not only the vehicles moving in the simulation, but can also display sensor contacts such as a line of bearing, detections and tracks.

JSAF enables what are known as "constructive simulations" [1]. These are simulations that involve the entire battle space with simulated ships, aircraft and other units controlled by simulation operators, who act behind the scenes to stimulate the people being trained, without directing the outcome of the event. As individuals in each unit react to contacts or new information and make a decision, those decisions are propagated to other units in the simulation and across the entire integrated joint warfighting team. These training simulations may require up to six months to prepare. Additional background on NCAMS (Navy Center for Advanced Modeling and Simulation) at NWDC is available in CHIPS, the Navy's information technology magazine at http://www.doncio.navy.mil/chips/ArticleDetails.aspx?ID=2297[1].

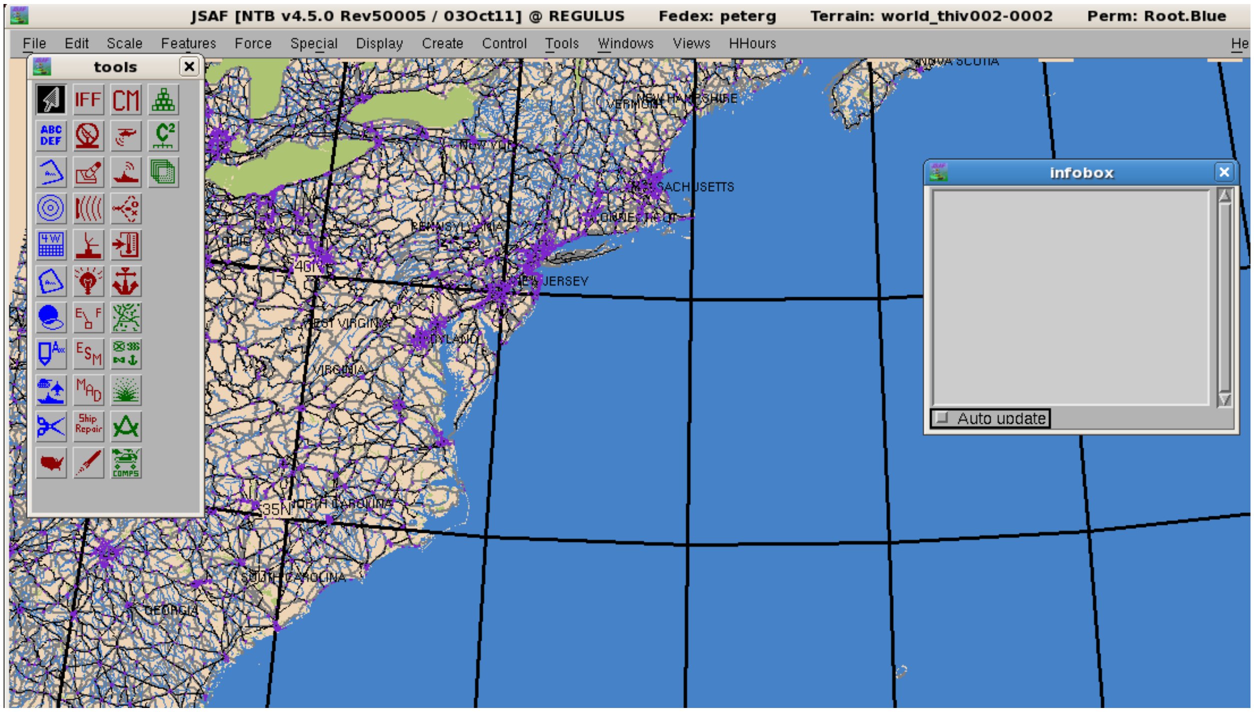

Figure 1. The Plan View Display (PVD) in JSAF.

2. Environmental Data

JSAF can be run either with uniform and constant environmental conditions or spatially and temporally varying environmental conditions. In the standalone mode, no time-varying data is available. The default conditions are constant in time and uniform in space and are given in Table 1 below[2].

Environmental Factor	Default Value
sun's position	noon
wind speed	0 mph
wind direction	east to west
cloud cover	10%
precipitation	none
visibility	infinite, subject to terrain

Table 1. Default environmental conditions, from Ref. 2.

The values of these environmental parameters can be changed via the environment editor icon  in the Tools menu as shown in Figure 2.

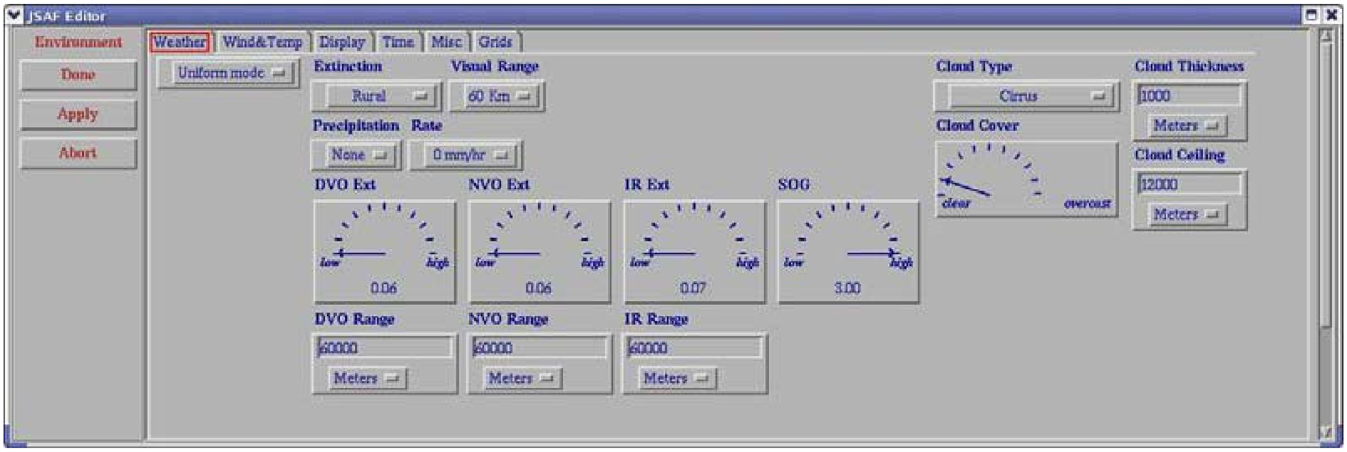

Figure 2. The JSAF environmental editor showing the default weather settings.

The interface for variables relevant to EM propagation and ducting are set through the Misc tab in the weather editor (Figure 3):

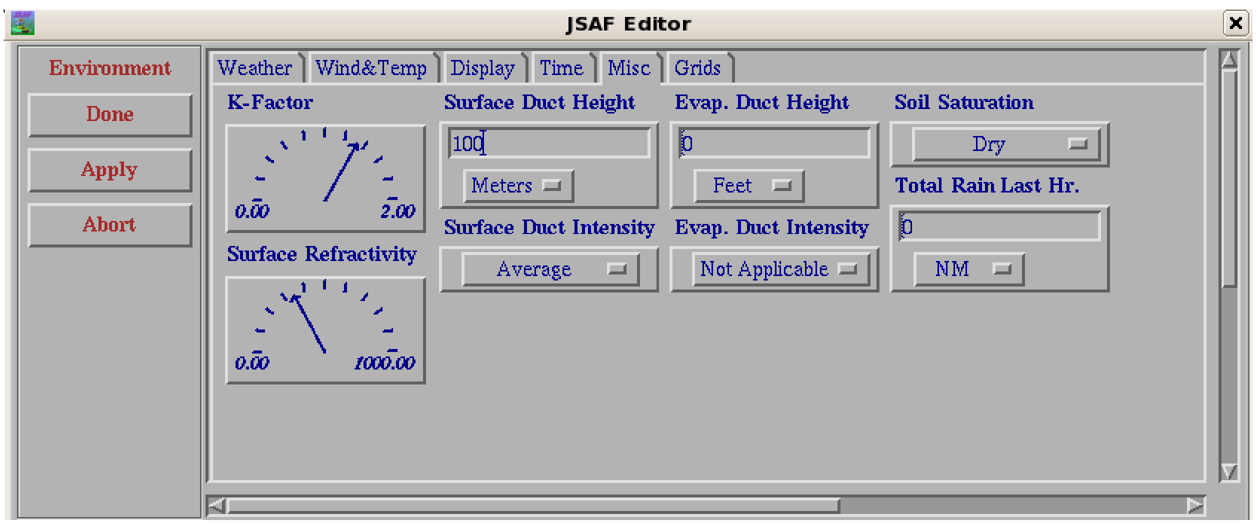

Figure 3. The Environment Editor to control EM propagation in JSAF.

Similarly, Figure 4 shows the interface for setting up ocean conditions, set by clicking on the Ocean Parameters editor icon .

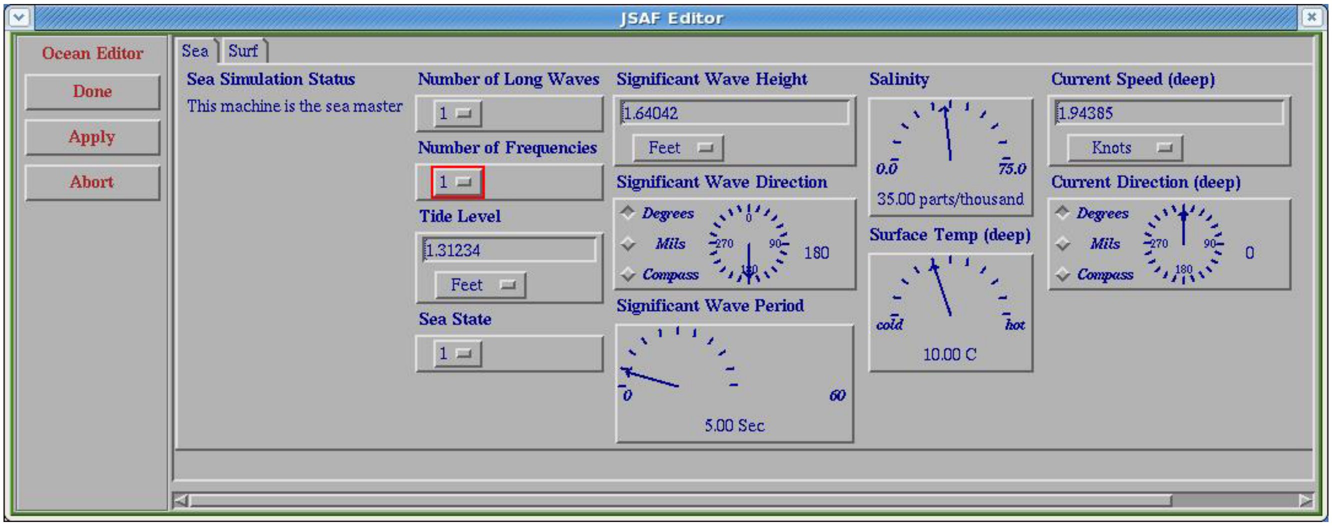

Figure 4. The Ocean Parameters editor in JSAF.

In this editor, tide level, sea state, and wave characteristics such as frequencies of long waves, significant wave height, direction, and period can be set. Surface temperature and salinity and deep current speed and direction can also be set.

For time-dependent environmental conditions, JSAF ingests weather and ocean data through the Environmental Data Cube Support System (EDCSS) plug-in, supported by CNMOC[3]. It is also possible to run without the EDCSS Distributor, and just run with weather data locally on the user's hard drive. Details and instructions are provided in the *Joint Simulation Bus (JBUS) User's Guide*[4].

The data available are either monthly climatologies, historical data from a specific date or the current day's data (not available as of January 2012). As depicted in Figure 5, climatologies are obtained from OAML (Oceanographic and Atmospheric Master Library), historical data is identified and extracted by CNMOC staff, or current conditions are provided by FNMOC (although this real-time capability is not currently available). Training events using JSAF typically use historical data from a period having the properties desired for the operational problem. The CNMOC METOC staff prepare event data using their Environmental Scenario Generator (ESG). The ESG queries the library, extracts the data, and converts it to the format needed. Most training events get acoustic environment data, visual sensor environment data and radar evaporative duct and surface duct data. The data is prepared in 2D and 3D gridded form for JSAF and also in the forms needed by the tactical decision aids such as PC-IMAT. The data prepared may also include forecast maps, forecast messages etc. for use by the trainees.[8] In addition, as shown in Figure 5, the EDCSS can produce synthetic observations, such as bathythermograph (BT) data, or synthetic imagery to be used in the training event.

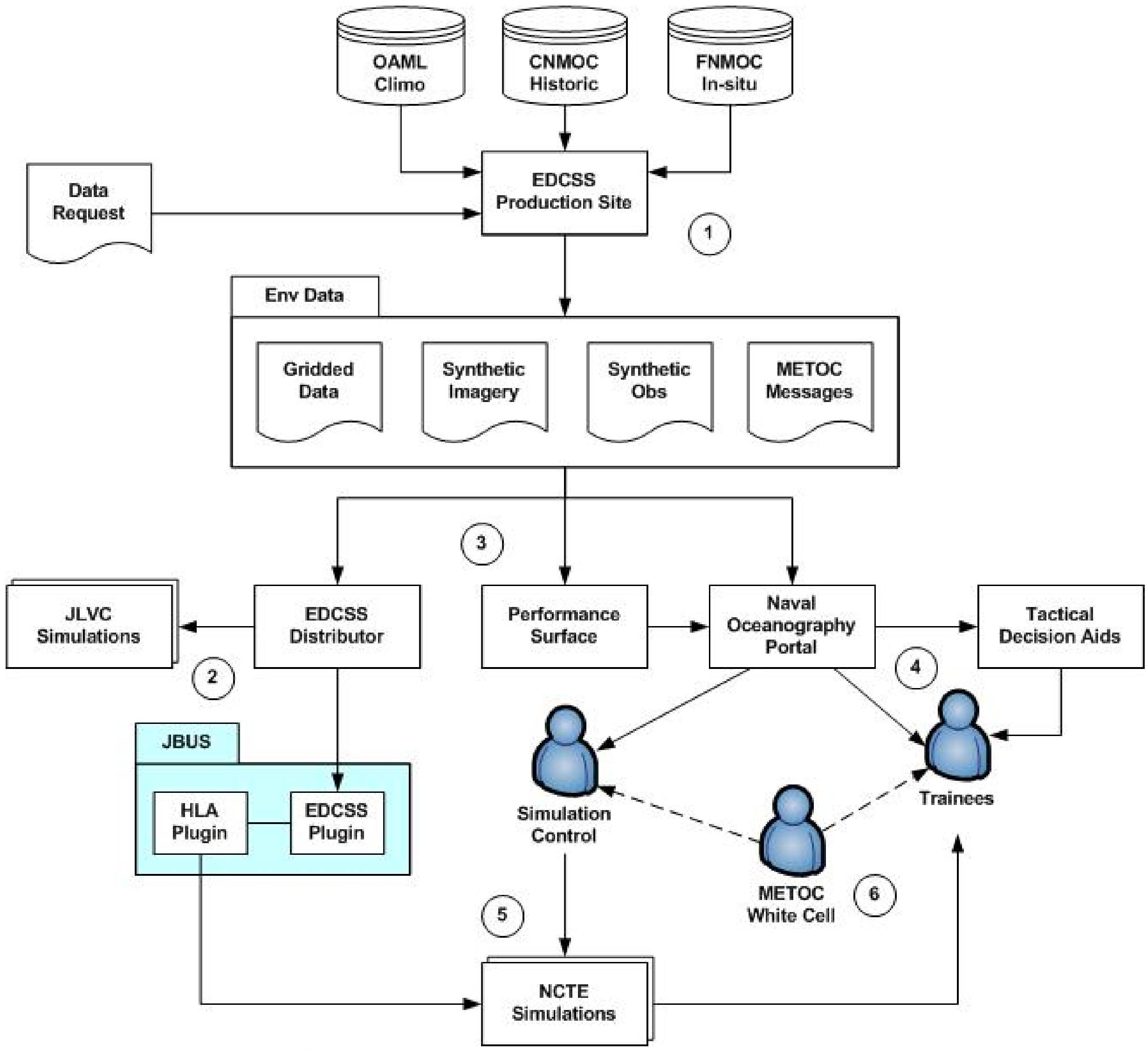

Figure 5. Schematic from Reference 5.

For the historical option, the following data is used (from Ref 9):

Ocean Sound Speed 3-D Grids

- Temperature
- Salinity

Surface Weather 2-D Grids (at 10 m)

- Air Temperature
- Surface Pressure
- Relative Humidity
- Surface Winds (U/V Components)
- Precipitation Rate and Type
- Visibility or Visual Extinction Coefficients
- Radar Duct Info (evap duct height, surface duct height, k factor, surface refractivity)

- Cloud and Fog cover (ceiling, max height, % cover, type)

Sea Conditions 2-D Grids

- Sea State Category or Significant Wave Height
- Surface Current (U/V components)

Typical grid spacings for the historic data are:

- 1/8 degree for sound speed data (NCOM)
- 1/2 degree for atmospheric data (COAMPS)
- 1/5 degree for sea surface data (WW3)

While JSAF is capable of using two-dimensional time varying data in electromagnetic propagation predictions, only the ocean data has been used in this way in the past, to make acoustic propagation loss predictions for use by the sonar sensors[5]. According to Reference 5, "Prior to an event, the client, operations and the local meteorology office review the training objectives, identify weather conditions appropriate to those objectives and search the available products for a period of data that has suitable weather conditions. The meteorology staff extracts this data and makes it available, either directly from EDCSS or as data sets in a form that can be published by the JBUS environmental data distributor." Note: "weather" includes both ocean and atmospheric conditions. For most training events, locally served file data is used rather than querying and using the data from web services.

The temporal sampling currently used changes every four hours, which is an appropriate time scale for ocean acoustic applications. However, for the atmosphere, Hamby (Ref 5) points out that the interval for meteorological sampling should be shorter to capture more rapidly changing conditions, or have non-uniform sampling in time, with more frequent sampling when needed, and less frequent say during the night time when conditions are changing more slowly.

For the ocean climatology, the data is extracted from the GDEM-V 3.0-050 (General Digital Environmental Model –Variable resolution) database, which provides bottom depth, ocean temperature and salinity profile data. For atmospheric variables, the data sources are not stated, but the Surface Marine Gridded Climatology (SMGC) is used for climatology and COAMPS output is used for historical data. The following table is from the JBUS EDCSS SDD documentation[6] and covers all the environmental data used in the Navy Continuous Training Environment (NCTE) – these are known as BOM (Base Object Model).

Class	Attribute Name	Data Type	Cardinality	Units
Cloud Layer GDC	EAC_Cloud_Base_Height	Gridded_Scalar_Field_2D	1	Meters
	EAC_Cloud_Cover_Fraction_Total	Gridded_Scalar_Field_2D	1	Dimensionless
	EAC_Cloud_Sky_Cover_Type	Gridded_Enumerated_Field_2D	1	N/A
	EAC_Cloud_Thickness	Gridded_Scalar_Field_2D	1	Meters

	EAC_Spatial_Geodetic_Latitude	Horizontal_Axis	1	N/A
	EAC_Spatial_Geodetic_Longitude	Horizontal_Axis	1	N/A
	Origin_Latitiude	Double	1	Degrees
	Origin_Longitude	Double	1	Degrees
Fog GDC	EAC_Fog_Cover	Gridded_Scalar_Field_2D	1	Dimensionless
	EAC_Fog_Extinction_Coefficient	Gridded_Scalar_Field_2D	1	1/meter
	EAC_Fog_Present	Gridded_Scalar_Field_2D	1	0.0 or 1.0
	EAC_Fog_Thickness	Gridded_Scalar_Field_2D	1	Meters
Radar Duct GDC	EAC_Evaporative_Duct_Altitude	Gridded_Scalar_Field_2D	1	Meters
	EAC_Evaporative_Duct_Index	Gridded_Scalar_Field_2D	1	Dimensionless
	EAC_Evaporative_Duct_Strength	Gridded_Enumerated_Field_2D	1	Dimensionless
	EAC_Surface_EM_Prop_Duct_Altitude	Gridded_Scalar_Field_2D	1	Meters
	EAC_Surface_EM_Prop_Duct_Strength	Gridded_Enumerated_Field_2D	1	Dimensionless
Surface Haze GDC	EAC_Obscurant_Type	Gridded_Enumerated_Field_2D	1	N/A
	Extinction_Coefficient_Far_IR	Gridded_Scalar_Field_2D	1	1/meter
	Extinction_Coefficient_Mid_IR	Gridded_Scalar_Field_2D	1	1/meter
	Extinction_Coefficient_Near_IR	Gridded_Scalar_Field_2D	1	1/meter
	Extinction_Coefficient_Visible	Gridded_Scalar_Field_2D	1	1/meter
	Reference_Height	Double	1	Meters
Surface Precipitation GDC	EAC_Precipitation_Rate	Gridded_Scalar_Field_2D	1	Mm/hr
	EAC_Precipitation_Type	Gridded_Enumerated_Field_2D	1	N/A
Surface Weather GDC	EAC_Air_Temperature	Gridded_Scalar_Field_2D	1	Degrees Celsius
	EAC_Atm_Pressure	Gridded_Scalar_Field_2D	1	Millibars
	EAC_Blowing_Sand	Gridded_Enumerated_Field_2D	1	N/A
	EAC_Blowing_Snow	Gridded_Enumerated_Field_2D	1	N/A
	EAC_Dewpoint_Depression	Gridded_Scalar_Field_2D	1	Degrees Celsius
	EAC_Relative_Humidity	Gridded_Scalar_Field_2D	1	Percent
	EAC_Wind_Speed_U_Component	Gridded_Scalar_Field_2D	1	Meters/sec
	EAC_Wind_Speed_V_Component	Gridded_Scalar_Field_2D	1	Meters/sec
	Reference_Height	Double	1	Meters

Class	Attribute Name	Data Type	Cardinality	Units
Ocean Surface Layer GDC	EAC_Current_U_Ocean	Gridded_Scalar_Field_2D	1	Meters/sec
	EAC_Current_V_Ocean	Gridded_Scalar_Field_2D	1	Meters/sec
	EAC_Tide_Level	Gridded_Scalar_Field_2D	1	Meters
Ocean Wave Spectrum GDC	EAC_Sea_State_Category	Gridded_Enumerated_Field_2D	1	N/A
	EAC_Wave_Direction_Primary	Gridded_Scalar_Field_2D	1	Degrees Heading
	EAC_Wave_Direction_Secondary	Gridded_Scalar_Field_2D	1	Degrees Heading
	EAC_Wave_Direction_Swell_Mean	Gridded_Scalar_Field_2D	1	Degrees Heading
	EAC_Wave_Direction_Wind_Induced_Mean	Gridded_Scalar_Field_2D	1	Degrees Heading
	EAC_Wave_Height_Maximum	Gridded_Scalar_Field_2D	1	Meters
	EAC_Wave_Height_Significant	Gridded_Scalar_Field_2D	1	Meters
	EAC_Wave_Height_Swell_Significant	Gridded_Scalar_Field_2D	1	Meters
	EAC_Wave_Height_Wind_Induced_Significant	Gridded_Scalar_Field_2D	1	Meters
	EAC_Wave_Period_Primary_Mean	Gridded_Scalar_Field_2D	1	Seconds
	EAC_Wave_Period_Secondary_Mean	Gridded_Scalar_Field_2D	1	Seconds
	EAC_Wave_Period_Swell_Mean	Gridded_Scalar_Field_2D	1	Seconds
	EAC_Wave_Period_Wind_Induced_Mean	Gridded_Scalar_Field_2D	1	Seconds

Class	Attribute Name	Data Type	Cardinality	Units
Ocean Volume GDC	EAC_Current_U	Gridded_Scalar_Field_3D	1	Meters/sec
	EAC_Current_V	Gridded_Scalar_Field_3D	1	Meters/sec
	EAC_Current_W	Gridded_Scalar_Field_3D	1	Meters/sec
	EAC_Salinity	Gridded_Scalar_Field_3D	1	Parts per Thousand
	EAC_Sea_Temperature	Gridded_Scalar_Field_3D	1	Degrees

			Celsius
EAC_Sound_Speed_Water	Gridded_Scalar_Field_3D	1	Meters/sec
EAC_Spatial_Elevation	Vertical_Axis	1	N/A
EAC_Spatial_Geodetic_Latitude	Horizontal_Axis	1	N/A
EAC_Spatial_Geodetic_Longitude	Horizontal_Axis	1	N/A
Origin_Elevation	Double	1	Meters
Origin_Latitude	Double	1	Degrees
Origin_Longitude	Double	1	Degrees

Table 2. Environmental variables and units that are provided by the EDCSS into JSAF, from *Environmental Data Cube Support System (EDCSS) Plugin for JBUS Software Design Description (SDD)*[6].

The Acoustic Transmission Loss Server (ATLOS) provides a conduit between the environmental system, such as the EDCSS, and sonar systems on the various vehicles[3]. The JSAF sonar models determine the acoustic source and passive receiver locations and depths and then send a transmission loss request to ATLOS. The transmission loss is calculated based on a new range-dependent broadband underwater acoustic propagation model called FeyRay, a fast 2-D Gaussian ray model. The environmental data are retrieved from the EDCSS data server via the JBUS (Joint Simulation Bus). The data include ocean temperature and salinity profiles, and surface conditions, bottom depth and bottom type which are obtained from static JSAF terrain databases. Typically the Estuarine and Coastal Ocean Model (ECOM), a variant of the Princeton Ocean Model (POM), is used for shallow water areas, and the Modular Ocean Data Assimilation System (MODAS) for deeper water. Inputs to the FeyRay model are (1) sound speed profiles along a great circle path from the source to the receiver; (2) bottom bathymetry along the path; (3) surface wind speed along the path; and (4) the bottom type along the path. The data are site-specific and are updated during the simulation to include diurnal and longer temporal effects[3].

3 References and Links

More detailed and comprehensive documentation of all the features in JSAF are available (although the site is password-protected) at http://confluence.nwdc.hpc.mil/display/JUG/Documentation and in the User Guides directory once the program is installed.

1. Navy Center for Advanced Modeling and Simulation, in CHIPS: The Department of the Navy's Information Technology Magazine. April –June 2011. http://www.doncio.navy.mil/chips/ArticleDetails.aspx?ID=2297

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5. JSAF Time Dependent Weather – NPS Software Development Collaboration:
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http://confluence.nwdc.hpc.mil/download/attachments/7865377/Environment+Data+Publication.pdf

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http://confluence.nwdc.hpc.mil/display/BL4ARCH/Meteorology+and+Oceanography+%28METOC%29

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